Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	**two marks** Cl in Cl_2 is 0 Goes to +1 in HClO Goes to –1 in HCl **(2)** All three correct for two marks Any two correct for one mark Ignore correct oxidation numbers for other elements If three correct numbers given without saying what species they are in max 1 for these two marks **Third mark** Cl/Cl_2/the same element is both oxidized and reduced Allow same molecule/species/ type of atom is both oxidized and reduced if answer elsewhere has been in terms of chlorine OR Cl/Cl_2/the same element both increases and decreases in oxidation number OR Chlorine both loses and gains electrons **(1)**	Only 'Cl^+' for oxidation number + Only 'Cl^-' for oxidation number - (treat each separately) For each incorrect oxidation number change for O and H, lose one mark. 0 to +1 described as reduction and/or 0 to -1 described as oxidation (for third mark)	**3**

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	Equilibrium moves to the left / moves in reverse direction / moves to increase concentration of reactants **(1)** To use up (some of) added HCl/ to react with added HCl/ to stop formation of HCl/ restores equilibrium by producing more chlorine and water **(1)** Second mark depends on first Allow 'moves to decrease concentration of products/HCl' for both marks	Just "reverse reaction is **favoured**" Just "to counteract the change in the system" To minimise effect of HCl	**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	$ClO^- + 2H^+ + 2e^{(-)} \rightarrow Cl^- + H_2O$ ALLOW $ClO^- + 2H^+ \rightarrow Cl^- + H_2O - 2e^{(-)}$ **(1)** $2I^- \rightarrow I_2 + 2e^{(-)}$ ALLOW $2I^- - 2e^{(-)} \rightarrow I_2$ **(1)** Allow multiples Ignore state symbols even if incorrect	Equations without electrons	**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	$ClO^- + 2H^+ + 2I^- \rightarrow Cl^- + H_2O + I_2$ Mark independently. No TE on 21(b)(i)	Equations including electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	Moles thiosulfate = (24.20 x 0.0500 / 1000) = 1.21×10^{-3} /1.2×10^{-3} /0.00121/ 0.0012 (mol) **(1)** Moles iodine = half moles of thiosulfate = 6.05×10^{-4} / 6.1×10^{-4} / 0.000605 / 0.00061 (mol) **(1)** Correct answer without working **(2)**	1.20×10^{-3} (mol) $1x\ 10^{-3}$/ 0.001 6.0×10^{-4} (mol) 6×10^{-4} (mol)	**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)(iv)	Moles ClO^- = 6.05×10^{-4} (mol) TE on (b)(ii) and (b)(iii): If ratio $ClO^- : I_2$ = 2:1 answer is 2 x answer to (b)(iii) If ratio $ClO^- : I_2$ = 1:2 answer is half of answer to (b)(iii)		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(v)	Concentration = ($6.05 \times 10^{-4} \times 1000/25$) = 2.42×10^{-2} / 0.0242/ 0.024/ 2.4×10^{-2} (mol dm^{-3}) TE. Answer to (b)(iv) x 1000÷ 25	Answers to 1 significant figure	**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(vi)	(Minimum) amount of I^- to react with OCl^- =2 x answer to (b)(iv) = $2 \times 6.05 \times 10^{-4}$ = 1.21×10^{-3} (mol) **(1)** Allow TE for 2 x answer to (b)(iv) Ignore s.f. Moles of I^- (9.04×10^{-3}) is more than this number of moles of ClO^- / I^- is in excess / KI is in excess / so that all the ClO^- can react **(1)** **OR** 9.04×10^{-3} mol I^- can react with 4.52×10^{-3} mol OCl^- **(1)** Ignore s.f. TE from incorrect equation in (b)(ii) Moles OCl^- (6.05×10^{-4}) is less than this/ I^- is in excess / KI is in excess / so that all the ClO^- can react **(1)**	"KI is in excess" if no calculation has been done.	**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)(vii)	0.30 x 100 / 24.2 (=1.2396694) = 1.24/ 1.2 %		**1**

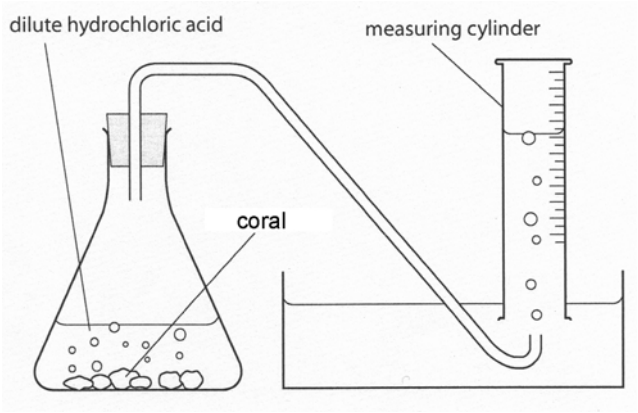
Question Number	Acceptable Answers	Reject	Mark
1(b)(viii)	Judgement (of colour change) at end point / adding starch too early in the titration / jet of burette not filled Errors must cause an increase in titre. Ignore Just “Human error” Just ‘overshot endpoint’ Transfer errors / spillage Errors due to misreading burette / pipette	Some potassium iodide did not dissolve Leaving funnel in burette Errors which affect both the students titre and an accurate titre using the same solutions **e**.g. impu solutions	**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)	(Cl radicals) break down ozone (layer)/ ozone depletion / ozone (layer) thinning Allow damage ozone (layer)/ react with ozone	Global warming Causes acid rain	**1**

Total = 17 marks

Question Number	Acceptable Answers	Reject	Mark
2 (a) (i)	$H_2O + CO_2 \rightarrow H_2CO_3$ (Allow atoms in H_2CO_3 in any order) Or $H_2O + CO_2 \rightarrow H^+ + HCO_3^-$ Or $H_2O + CO_2 \rightarrow 2H^+ + CO_3^{2-}$ Or H_3O^+ in place of H^+ *IGNORE STATE SYMBOLS EVEN IF INCORRECT*		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (ii)	$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$ LHS **(1)** RHS **(1)** **OR** $2H_3O^+ + CO_3^{2-} \rightarrow 3H_2O + CO_2$ LHS **(1)** RHS **(1)** *IGNORE STATE SYMBOLS, EVEN IF INCORRECT* *IGNORE* ⇌ arrows	H_2CO_3 as a product $H^+ + CO_3^{2-} \rightarrow HCO_3^-$ Any other ions including spectator ions (e.g. Ca^{2+}, Cl^-) in the equation scores zero	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (i)	 Conical flask **and** a delivery tube leaving the conical flask **(1)** *IGNORE* "heat" beneath conical flask Inverted measuring cylinder with collection over water shown and cylinder above mouth of delivery tube **(1)** *ALLOW* collection over water to be shown/implied in the diagram without labels or other annotation	If collection **over water** is not somehow evident	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (ii)	Any method which is likely to bring the reactants into contact **after the apparatus is sealed**	Method suggesting mixing the reactants and then putting bung in flask very quickly	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (iii)	(224 ÷ 24000 =) 0.009333/9.333 x 10^{-3} (mol) **Ignore SF except 1 SF** **Ignore any incorrect units**	"0.009" as answer	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (iv)	$CaCO_3$(**s**) + 2HCl(**aq**) → $CaCl_2$(**aq**) + H_2O(**l**) + CO_2 (**g/aq**) **ALL FOUR** state symbols must be correct for this mark		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (v)	(Mass of 1 mol $CaCO_3$ = 40 + 12 + 3 x 16) = **100** g *ALLOW* just "100" *ALLOW* any incorrect units *ALLOW* "100.1 g " *OR* just "100.1" (Reason: this uses the Periodic Table value of A_r = 40.1 for Ca)		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (vi)	(Mass of $CaCO_3$ = 100 x 0.009333) = 0.9333 (g) **(1)** *IGNORE* sig figs including 1 sf here **NOTE:** Moles of $CaCO_3$ consequential on answers to (b)(iii) and (b)(v) [**NOTE**: if A_r = 40.1 used for Ca, then the answer = 0.9339 (g)] Percentage of $CaCO_3$ in the coral = 100 x 0.9333 /1.13 = 82.6% **(1)** **NOTE:** If mass $CaCO_3$ used is 0.93, final answer is 82.3% [**NOTE***:* if A_r = 40.1 used for Ca, then the answers = 0.9339 (g) and **82.7**%]	Final **%** answer is **not given to 3 sf**	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (vii)	(Different samples of) coral have different amounts of **$CaCO_3$** /different proportions of **$CaCO_3$** / different "levels" of **$CaCO_3$** *ALLOW* "calcium carbonate" for **$CaCO_3$** OR Only one sample of coral (was) used	Answers that do not include any mention of $CaCO_3$ References to solubility of CO_2 in water References to repeating the experiment at a different temperature	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (i)	$(COOH)_2 \rightarrow 2CO_2 + 2H^+ + 2e^-$ **(1)** $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (ii)	$5(COOH)_2 + 2MnO_4^- + 6H^+ \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$ ALLOW multiples ALLOW $5(COOH)_2 + 2MnO_4^- + 16H^+ \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O + 10H^+$ Ignore state symbols even if incorrect	Equation with electrons left in	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (iii)	Moles of MnO_4^- = 11.30/1000 x 0.010 = 1.13×10^{-4} (mol) **(1)** Moles of $(COOH)_2$ in 10 cm^3 = 1.13×10^{-4} x 5/2 = 2.825×10^{-4} (mol) **(1)** Moles of $(COOH)_2$ in whole sample = 2.825×10^{-4} x 50 = 0.01412(5) (mol) **(1)** Mass of acid = 0.01412(5)x 90 = 1.27 g **(1)** % in leaves = 1.27/250 x 100 = 0.51 (%) **(1)** If ratio 5 : 2 is not used, maximum **(4)** e.g. if ratio 2:5 is used then percentage in leaves = 0.08%	TE for 5th mark if % is greater than 100% Rounding errors once in first 4 marks Final answers not quoted to 2 dp	**5**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (iv)	± 0.05 cm^3 **(1)** [(0.05 x 2) / 11.3] x 100 = 0.88% **(1)** ALLOW ±0.025 cm^3 **(1)** [(0.025 x 2) / 11.3] x 100 = 0.44% **(1)** ALLOW TE for second mark		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (v)	Any two from: Only one titration carried out **(1)** Leaves may contain other substances that MnO_4^- could oxidize/ react with **(1)** Not all ethanedioic acid extracted from leaves **(1)** ALLOW temperature too low / below 60°C **(1)** Different amounts of acid from different leaves **(1)**	Errors in technique e.g. transfer errors	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (vi)	(Wearing gloves suggested as) ethanedioic acid is toxic / harmful OR rhubarb **leaves** are toxic /harmful **(1)** (Unnecessary because) it is (very) dilute / present in small amounts **(1)** ALLOW because is not absorbed through the skin **Second mark is independent of the first**	References to weak acid Rhubarb is toxic	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (vii)	(Cloudiness due to) **MnO_2** (solid /precipitate) **(1)** Ignore colour of precipitate EITHER Suitable use of E^θ (+0.34V) **OR** MnO_4^- ions are a strong enough oxidizing agent to oxidize Cl^- ions **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (i)	$(1s^2)2s^22p^63s^23p^63d^5$ $(4s^0)$	$4s^2$ $3d^3$	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (ii)	Octahedral		**1**